UNIVERSITI PUTRA MALAYSIA

OPTIMIZATION OF PROCESS CONDITIONS AND EMULSION COMPOSITION, AND THEIR EFFECTS ON EMULSION AND ENCAPSULATION PROPERTIES OF SPRAY-DRIED FISH OIL POWDER

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FSTM 2012 11

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By

MINA TIRGAR

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

June 2012

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

OPTIMIZATION OF PROCESS CONDITIONS AND EMULSION COMPOSITION, AND THEIR EFFECTS ON EMULSION AND ENCAPSULATION PROPERTIES OF SPRAY-DRIED FISH OIL POWDER

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Chairman : Prof. Jinap Selamat, PhD

Faculty : Food Science and Technology

Fish oil is the richest dietary source of long-chain polyunsaturated fatty acids (LC-PUFAs), but it is prone to oxidative deterioration when exposed to oxygen. The purpose of this study was to produce microencapsulated fish oil powder using spray-drying technology. This study was performed in order to 1) screen the most suitable coating material and optimize the best emulsion formulation for the production of microencapsulated fish oil powder and 2) optimize the spray-drying parameters to produce microencapsulated fish oil powder with the best encapsulation properties. To meet the first objective, three coating materials were used: maltodextrin (15, 25% w/w), Arabic gum (2.5, 7.5% w/w), and methylcellulose (0.5, 1.5% w/w). In addition, the emulsion composition was optimized according to two factors: the fish oil content (6-12% w/w) and the coating material (15–31% w/w) using response surface methodology

(RSM). The results indicated that Arabic gum (5% w/w) had the most significant ($p < 0.05$) effect on the surface mean diameter of the emulsion. Maltodextrin had the most significant ($p < 0.05$) effect on the centrifugal stability of the emulsion and the amount of surface oil of the powder at 15 and 20% (w/w) respectively, whereas methylcellulose (0.5% w/w) had the most significant ($p < 0.05$) effect on the width distribution of the droplets in the emulsion. The oil content (11% w/w) had the most significant ($p < 0.05$) effect on the centrifugal stability and the creaming stability of the emulsion. In addition, oil content (9% w/w) had the most significant effect on the moisture content of the powders. Whereas the interaction between the coating and the oil had the most significant ($p < 0.05$) effects on the surface mean diameter of the powder.

In the second objective, the temperature (140-200 ˚C), pressure (1-5 kgf/cm^2) and feed flow rate of the emulsion (5-20 ml/min) were applied to optimize the spray-drying parameters using RSM. The results indicated that pressure had the most decreasing effect on the average particle size and the amount of surface oil at 4 and 3 kgf/cm^2 respectively. Moreover, pressure (4 kgf/cm^2) had the most increasing effect on microencapsulation efficiency, and the interaction between this factor and the temperature revealed the most significant ($p < 0.05$) effect on total oil extraction. The flow rate had the most significant ($p < 0.05$) effect on the uniformity and color at 7 and 17 ml/min, respectively. No significant ($p > 0.05$) differences were observed between the experimental and predicted values; this verified that the used model for this study was suitable.

A fish oil emulsion containing 17.30% (w/w) coating material consisting of 11.85% (w/w) maltodextrin, 4.80% (w/w) Arabic gum, and 0.65% (w/w) methylcellulose with 11.48% (w/w) oil content and 71.22% (w/w) deionized water was predicted to produce the best coating material and emulsion composition for the encapsulation of fish oil powder. An inlet temperature of 153 °C, pressure of 4 kgf/cm^2 and feed flow rate of emulsion of 17 ml/min were demonstrated to be the optimum conditions for producing encapsulated fish oil powder.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENGOPTIMUMAN DARI SYARAT PROSES DAN KOMPOSISI EMULSI, DAN KESANNYA KE ATAS CIRI-CIRI EMULSI DAN PENGKAPSULAN SEMBURAN-KERING SERBUK MINYAK IKAN

Oleh

MINA TIRGAR

Jun 2012

Pengerusi : Prof. Jinap Selamat, PhD

Fakulti : Sains dan Teknologi Makanan

Minyak ikan adalah sumber diet terkaya bagi rantai panjang asid lemak politaktepu (LC-PUFA), tetapi ia cepat mengalami kemerosotan oksidatif apabila terdedah kepada oksigen. Tujuan kajian ini adalah untuk menghasilkan serbuk minyak ikan terkapsul mikro dengan menggunakan teknologi pengeringan semburan. Kajian ini telah dilakukan untuk: 1) menyaring bahan salutan yang paling sesuai dan mengoptimumkan formulasi emulsi terbaik untuk pengeluaran serbuk minyak ikan terkapsul dan 2) untuk mengoptimumkan parameter pengeringan semburan untuk menghasilkan serbuk minyak ikan terkapsul dengan sifat pengkapsulan terbaik. Untuk memenuhi objektif pertama, tiga bahan salutan telah digunakan: maltodekstrin (15, 25% w/w), gum arab (2.5, 7.5% w/w), dan metilselulosa (0.5, 1.5% w/w). Disamping itu, komposisi emulsi telah dioptimumkan menggunakan dua faktor: kandungan minyak ikan (6-12% w/w) dan

kandungan bahan salutan (15-31% w/w) dengan menggunakan kaedah gerak balas permukaan (RSM). Keputusan menunjukkan gum arab (5% w/w) mempunyai kesan yang paling ketara ($p < 0.05$) pada purata garis pusat permukaan emulsi. Maltodekstrin mempunyai kesan yang paling ketara ($p < 0.05$) terhadap kestabilan empar emulsi dan jumlah permukaan minyak serbuk pada 15 dan 20% w/w masing-masing, manakala metilselulosa (0.5% w/w) menunjukkan kesan yang paling ketara ($p < 0.05$) ke atas taburan lebar titisan dalam emulsi. Kandungan minyak (11% w/w) mempunyai kesan yang paling ketara ($p < 0.05$) terhadap kestabilan empar dan kestabilan mengkrim emulsi. Di samping itu, kandungan minyak (9% w/w) mempunyai kesan yang ketara ke atas kandungan lembapan serbuk. Manakala interaksi antara lapisan dan minyak mempunyai kesan paling ketara ($p < 0.05$) ke atas purata garis pusat permukaan serbuk.

Dalam objektif kedua, suhu (140-200 ˚C), tekanan (1-5 kgf/cm^2) dan kadar suapan aliran emulsi (5-20 ml/min) telah digunakan untuk mendapatkan parameter optimum bagi pengeringan semburan dengan menggunakan RSM. Hasil kajian menunjukkan tekanan mempunyai kesan paling kurang ke atas purata saiz zarah dan jumlah permukaan minyak pada 4 dan 3 kgf/cm^2 masing-masing. Tambahan pula, tekanan (4 kgf/cm^2) mempunyai kesan yang paling meningkat pada kecekapan pemikrokapsulan, dan interaksi antara faktor ini dan suhu memberi kesan yang paling ketara ($p < 0.05$) pada jumlah minyak terekstrak. Kadar aliran mempunyai kesan yang paling ketara ($p < 0.05$) pada keseragaman dan warna pada 7 dan 17 ml/min, masing-masing. Tiada perbezaan yang ketara ($p > 0.05$) telah diperhatikan di antara nilai eksperimen dan ramalan; ini mengesahkan model yang digunakan dalam kajian ini adalah sesuai.

Emulsi minyak ikan yang mengandungi 17.30% (w/w) bahan salutan yang terdiri daripada 11.85% (w/w) maltodekstrin, 4.80% (w/w) gum arab, dan 0.65% (w/w) metilselulosa serta 11.48% (w/w) kandungan minyak dan 71.22% (w/w) air ternyahion telah diramalkan untuk menghasilkan bahan salutan dan komposisi emulsi yang terbaik untuk serbuk minyak ikan terkapsul. Suhu masuk 153 °C, tekanan 4 kgf/cm^2 dan kadar suapan aliran emulsi sebanyak 17 ml/min telah menunjukkan keadaan optimum untuk menghasilkan serbuk minyak ikan terkapsul.

ACKNOWLEDGEMENT

First of all, I thank God for allowing me to complete my MSc thesis. I am honored and grateful to have the full support from a number of persons in my life for their commitment during my Master's degree.

I would like to express my sincere appreciation and gratitude to Professor Dr. Jinap Selamat for her kindness, support and guidance in all throughout my MSc program.

Special thanks are expressed to Dr. Seyed Hamed Mirhosseini and Professor Zaidul Islam Sarker, the members of my supervisory committee, for their helpful suggestions throughout my research.

My warmest thanks go also to my parents and husband, Mohsen Kakoienejad. I cannot express how much I would like to say thank you to them for their love and supporting me from day one. They have always been there for me no matter what the situation and I am forever in their debt.

Also, many thanks to my dear friend Navideh Anarjan, I couldn't have completed this research without her support, friendship and encouragement.

I certify that an Examination Committee has met on 29 / 06 / 2012 to conduct the final examination of Mina Tirgar on her Master of Science thesis entitled "Optimization of process conditions and emulsion composition and their effects on the emulsion and encapsulation properties of spray-dried fish oil powder."

Members of the Thesis Examination Committee were as follows:

Name of Chairman, PhD
Title
Name of Faculty
Universiti Putra Malaysia
(Chairman)

Name of Examiner 1, PhD
Title
Name of Faculty
Universiti Putra Malaysia
(Internal Examiner)

Name of Examiner 2, PhD
Title
Name of Faculty
Universiti Putra Malaysia
(Internal Examiner)

Name of External Examiner, PhD
Title
Name of Department and/ or Faculty
Name of Organization (University / Institute)
(External Examiner)

SIEW HENG FONG, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis was submitted to the Senate of Universit Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Jinap Selamat, PhD
Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Chairman)

Seyed Hamed Mirhosseini, PhD
Lecturer
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Member)

Zaidul Islam Sarker, PhD
Professor
Faculty of Pharmacy
International Islamic University Malaysia
(Member)

BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or other institutions.

MINA TIRGAR

Date: 29 June 2012

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